Effects of Time of Weaning, Supplement, and Sire Breed of Calf During the Fall Grazing Period on Cow and Calf Performance[1,2]

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ABSTRACT: A 4-yr experiment was conducted to determine effects of protein supplementation, age at weaning, and calf sire breed on cow and calf performance during fall grazing. Each year 48 pregnant, crossbred cows nursing steer calves ($\bar{x}$ calving date = April 8) were assigned to a 2 × 2 × 2 factorial experiment replicated in three native range pastures. Treatment factors were: 1) no supplement (NS) or an individually fed supplement (S, 3 kg of a 34% protein supplement fed to cows every 3rd d); 2) calves weaned at the beginning (W, mid to late September) or at the end (NW, mid to late December) of the trial each year; or 3) calves sired by Hereford or Charolais bulls. Data were adjusted for cow size (initial hip height and initial and final weights and condition scores) by analyses of covariance using principal component coefficients as covariates. Change in cow weight and condition score were increased by S and W ($P < .01$), but these responses interacted and were not the same each year (yr × S, year × W, and year × S × W, $P < .01$). Forage intake was decreased ($P < .1$) by S and W. Total intake (forage + supplement) was not affected by S but was decreased by W ($P < .1$). Digestibility of OM was decreased by S ($P < .01$). Some carryover effects of treatments were observed the next spring in cow weight, condition score, and birth weight (NW decreased birth weight by 2 kg, $P < .01$), but there were no effects by the next fall on weaning weights or pregnancy rates. Milk yield decreased during the experimental period, and S maintained higher milk production in late lactation ($P < .01$). Calf ADG was increased by S and Charolais sires ($P < .01$). Efficiency (grams of output/megacalorie of input) was not affected by sire breed but was enhanced by S ($P < .01$). Our conclusions are that 1) effects of feeding a 34% protein supplement to cows were to increase calf gains and improve persistency of lactation and efficiency; 2) delaying weaning decreased cow weight and condition score; 3) effects of weaning age and protein supplementation were highly dependent on forage and environmental conditions in any given year; and 4) whatever effects existed in a given year did not carry over to effects on next year's production as measured by pregnancy rates and weaning weights.

Key Words: Beef Cattle, Grazing, Supplementation, Age at Weaning

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Introduction

Production efficiency is a function of both input and output of a production unit, and both must be measured in order to assess effects of treatments on efficiency. The output portion of production efficiency in a cow-calf production unit is a function of weaning weight and number of calves weaned (Dickerson, 1970; Wiltbank, 1994). Weaning weight can be increased by genetic (crossbreeding, growth potential)

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and environmental (creep feeding) manipulations or by age of calf (calving earlier and[or] weaning later). Number of calves weaned per herd is partially determined by several reproductive traits (puberty, anestrus, fertility), and these traits are affected by both genetic and environmental variables (Bellows and Short, 1994; Wiltbank, 1994). Nutritional status is the primary determinant of reproductive potential with weight and(or) body condition score being the most effective ways to monitor nutritional status (Randel, 1990; Short et al., 1990; Kunkle et al., 1994; Wetteman, 1994). Production efficiency can be enhanced by using nonharvested forage (Lamb et al., 1996), but nutrient availability in forage can be limiting as forage matures. Nutritional status of cattle grazing mature native range forage can be increased with appropriate supplementation (Kartchner, 1980; Adams et al., 1986; Sanson et al., 1990).

The objectives of this study were to determine the effects of cow size, genetic (and high vs moderate growth potential of the calf), and management variables (calves weaned or calves left on cows and cows supplemented or not) on forage intake and various measures of cow and calf performance during the fall grazing period and the effect that these variables had on subsequent production.

Materials and Methods

Animals, Treatments, and General Procedures

Forty-eight crossbred, mature cows (Table 1) with steer calves (average calving date April 8) were assigned at random to one of eight treatments in a 2 × 2 × 2 factorial experiment that started in late September of each year. There were three blocks of two pastures each and each block contained 16 cows (two cows treated alike in each block). The experiment was repeated in four consecutive years (1989 to 1992). Within a block all cattle were grazed in one of the two pastures until early November and then were moved to the second pasture for the remainder of the experiment. Stocking rates were moderate. All cows were lactating and were confirmed pregnant by rectal palpation at the start of the experiment each year.

The three experimental factors were 1) supplement or no supplement, 2) weaning at the beginning or end of the experiment (September vs December), and 3) calves sired by Hereford or Charolais bulls. A protein supplement was individually fed every 3rd d (3 kg/feeding; ingredients on an as-fed basis, 50% soybean meal, 25% barley, and 25% wheat; composition, 93.8% OM, 29.9% CP, 15.0% NDF, and 7.3% ADF) by gathering all cattle in one replicate each day and feeding supplemented cows individually in small pens. Each year calves were sired by AI by one of two bulls selected within each breed. Hereford bulls were selected from our Ft. Keogh Line 1 herd (MacNeil et al., 1992) based on an average yearling weight index, and Charolais bulls were selected from breeders and AI studs on the basis of having high yearling weight indexes. Sires do not represent breeds but rather were specifically selected to represent fixed genotypes for moderate growth and high fattening potential (Line 1 Hereford) vs high growth and low fattening potential (Charolais). For simplicity, sires will be referred to as Hereford and Charolais even though they represent specific, fixed genotypes rather than breeds.

Hip heights of cows were taken only at the beginning of the experiment each year, whereas body weights for cows and calves and body condition scores of cows were obtained at the beginning and end of the experiment each year. Body condition scores were the average of three independent scores assigned on the basis of 1 = thinnest to 10 = fattest.

Milk production estimates (12 h) were made in October and December by weigh-suckle-weigh (Knapp and Black, 1941) with each estimate being an average of two observations taken 7 d (October) or 12 d (December) apart. At the end of the experiment each year the calves on the suckled cows were weaned, and all cows were returned to the main herd (~300 cows), where they were wintered on range, supplemented with hay and barley pellets as required, calved out, rebred the next summer by AI during a 45-d breeding season, and weaned the next fall. Data collected during the subsequent winter, spring, and summer (cow and calf weights, cow condition score, and pregnancy) were used to determine the effects of experimental treatments during the previous fall on subsequent performance.

This research was conducted with approval from the Fort Keogh Animal Care and Use Committee.

Study Site

This experiment was conducted at the Hogback Grazing Unit, Ft. Keogh Livestock and Range Research Laboratory, ARS, USDA near Miles City, MT (46°22′ N, 105°53′ W). This 361-ha grazing unit has a rolling hills topography with six pastures arranged in a pie pattern around a central well and corral facility. Major forage species were western wheatgrass (*Pascopyrum smithii* [Rydb.] Love), blue grama (*Bouteloua gracilis* [H.B.K.] Lag ex Griffths), needle-and-thread (*Stipa comata* Trin. and Rupr.), buffalo grass (*Buchloe dactyloides* [Nutt.] Engelm.), threadleaf sedge (*Carex filifolia* Nutt.), cheatgrass (*Bromus tectorum* L.), Japanese brome (*Bromus japonicus* Thunb.), and various forbs.

Annual precipitation profiles during the study (Figure 1, starting with 1988, the year before the experiment started) were quite variable: 1988 was a very dry year, 1989 and 1990 had adequate moisture early with dry falls, 1991 was a very wet year with September precipitation almost four times normal, and 1992 was consistently 10 to 20% above normal.

Table 1. Summary of cow measurements at the beginning of the experiment each year

Variable and year	$\bar{x}$	SE	Range
Cow wt, kg			
1989	521	79	402 to 727
1990	574	68	455 to 749
1991	570	59	443 to 760
1992	562	43	482 to 660
Body condition score[a]			
1989	5.6	1.1	3 to 8
1990	5.5	.67	4 to 7
1991	5.8	.75	4 to 7
1992	5.5	.85	4 to 7
Cow age, yr			
1989	5.1	2.7	2 to 11
1990	5.9	2.1	3 to 11
1991	6.0	2.1	3 to 10
1992	7.1	2.3	3 to 12

[a]1 = thinnest to 10 = fattest.

Forage Intake

Forage intake was estimated in December of each year. On d 1 of the intake trial, cattle were given a sustained release chromic oxide bolus (Captec®, Nufarm, Auckland, New Zealand), and on d 6, three yearling or mature steers and two to four suckling calves were fitted with fecal bags for total collection of feces to provide a correction factor for release rate of chromic oxide from the bolus (Adams et al., 1991a; Hollingsworth et al., 1995). On d 7 through d 11, all cattle were gathered once each morning for collection of fecal grab samples. Fecal bags on bagged animals were weighed and emptied each morning with a subsample saved for chemical analysis.

Fecal samples were dried in a forced-air oven at 55°C until dry. Samples from d 7 through 10 were then composited on an equal dry weight basis. Samples from d 11 were kept separate and used to determine whether a bolus had been lost or malfunctioned during the week of sampling. Analysis on fecal samples included DM, ash (AOAC, 1990), Cr (Williams et al., 1962), and indigestible NDF (**INDF**; Cochran et al., 1986).

Organic matter intake was estimated by dividing the fecal OM output attributed to forage by the diet indigestibility determined using INDF as a digestibility marker (Cochran et al., 1986). Organic matter intake was converted to megacalories of DE using equations from Rittenhouse et al. (1971) and then to megacalories of ME (ME = .82 DE). Supplemented cows were estimated to consume 3.21 Mcal ME of supplement daily in addition to forage. For calves, fecal output contributed from milk was subtracted from total fecal output to obtain fecal output from forage. Fecal output from milk was estimated from the assumptions that fluid milk contained 12% solids and that milk solids were 92% digestible (Baker et al., 1976).

Diet Quality

Each year esophageal fistulas were established in suckling beef calves at an average of 34 d of age (average BW 65 kg) with the procedure described by Adams et al. (1991b). Esophageal extrusa was collected from suckling calves and mature esophageally fistulated cattle within 1 wk of the fecal sampling to estimate forage OMD to use in determining forage intake from fecal output. In 1989 and 1990, five calves and five mature steers were used; in 1991, three calves and three mature steers were used; and in 1992, three calves and five mature cows were used to collect esophageal extrusa. Esophageally fistulated cattle were penned at 1600 the day before collections were made. Water was available in the pens, but the animals did not have access to feed. Collections were

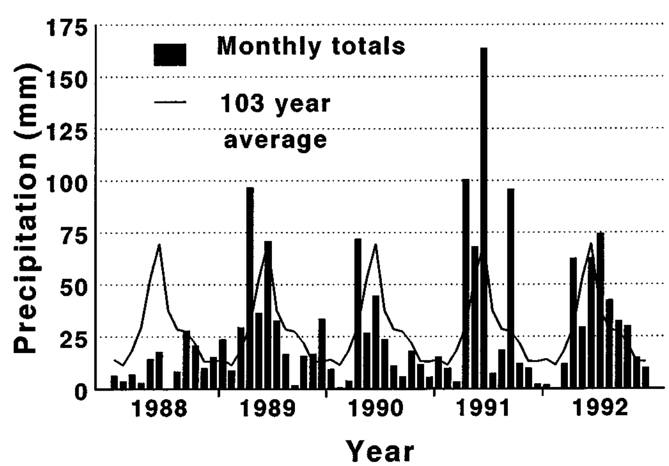

Figure 1. Monthly precipitation profiles during the year for 1988 through 1992 as compared to a 103-yr average.

made the following morning at 0700 by allowing both age groups to graze in the same area for 20 to 30 min. Collections were repeated over 3 d to obtain samples from all pastures being grazed by experimental animals. In 1989 and 1990, extrusa was dried at 45°C and ground to pass through a 1-mm screen in a Wiley mill before analysis. In 1991 and 1992, samples were placed immediately on ice until return to the laboratory where they were frozen, lyophilized, and ground. Analysis of esophageal extrusa included DM, ash, CP (Hach, 1987), NDF, ADL (Goering and Van Soest, 1970), ADF (AOAC, 1990), and INDF.

Forage Quality and Production

In 1991 and 1992, herbage quantity and quality were measured at the time of intake trials. Standing crop was estimated by harvesting 20 to 30 randomly located quadrats (.25 m^2) per pasture. Herbage was clipped by species to ground level and bagged. Herbage was dried at 55°C for 48 h and weighed to determine kilograms of DM/hectare. Herbage samples were then ground to pass a 1-mm screen in a Wiley mill and analyzed for DM, ash, CP (Hach, 1987), NDF, ADL (Goering and Van Soest, 1970), and ADF (AOAC, 1990).

Statistical Analyses

Data were analyzed using the procedures of SAS (1990). In order to reduce the number of variables involved in dam size and their colinearity, a principal component analysis of cow weights, condition scores, and hip height was conducted. The data were preadjusted for joint effects of year and age using general linear models methodology. The residuals were subjected to the principal component analysis. The first (size 1, **S1**) and second (size 2, **S2**) principal component coefficients used in further analysis resulted from this analysis of residuals. Cow data were analyzed in a model containing S1, S2, and S1·S2 as covariates, weaning, supplement, and year as main factors, main effect interactions, and block nested within year. Calf data were analyzed in a model that contained breed, supplement, year, interactions of these three main effects, and block nested within year.

Efficiency of the production system (grams of weight gain/megacalories of ME intake) was estimated by 1) dividing calf gain by forage intake of the cow and calf, 2) dividing calf gain by forage and supplement intake of the cow and calf, 3) dividing calf + cow gain by forage intake of the cow and calf, or 4) dividing calf + cow gain by forage and supplement intake of the cow and calf. Forage intake of cows and calves for the experimental period was obtained by multiplying the number of experimental days by the daily estimate of forage intake. Efficiency was analyzed in a model with milk and cow size as covariates and year, breed, supplement, interactions of these three, and block nested within year as class variables.

Results

Diet and Forage Data (Table 2)

In 1989 (dry fall following a drought year), we did not have a quantitative estimate of available forage from clipped plots. However, late spring standing crop data from adjacent pastures (Haferkamp et al., 1993), when coupled with precipitation data (Figure 1), suggest that forage mass in 1989 would have been well below that of 1991 and 1992. Only one estimate of quality was available in October of 1989 and quality was already low at that point. In 1990 (dry fall but normal total precipitation during previous year), we again did not have clipped data for estimating forage availability, but the late spring data from the adjacent range study, when coupled with precipitation data, showed that forage mass would have been greater than the previous year but still less than 1991 or 1992. Diet quality estimated from calves was higher in October of 1991 than in 1989, and it declined as expected in December; however, diet quality estimated from cows was the same in 1990 as it was in 1989 and October and December estimates were similar. In 1991 (high precipitation all year), amount of forage available was high and forage and diet quality remained high throughout the trial period. In 1992 (precipitation consistently above average), amount of forage available was less than the previous year, but production was still considered high for this unit, and just as in 1991, forage quality remained quite high throughout the period.

Cow Variables

The variables of initial weight, final weight, initial condition score, final condition score, and hip height were included in the principal components analysis of residuals. In this analysis, correlation between initial and final weight was .94 and between initial and final condition score was .71. Average correlations among two weights, two condition scores, and hip height were as follows: weight with condition score, .29; weight with hip height, .63; and condition score with hip height, –.03. The first two principal components, S1 and S2, accounted for 54 and 31% of the collective variation in residual weight, condition score, and hip height. In both S1 and S2, little within-trait variation in the loading was given to either weights or condition scores. The first principal component had positive loadings for weights (.56), condition scores (.31), and hip height (.40). Thus, cows having large values for S1 were relatively heavier with greater condition score and hip height than cows with small values for S1. The second principal component had negative loadings for cow weight (–.17) and hip height (–.46) but positive loading for condition score (.60). Thus, cows having large values for S2 were relatively lighter in weight and shorter in stature but had greater

Table 2. Forage production and diet quality as affected by year, month, and source

Month and source[a]	Forage production, kg/ha	Forage quality indicator, %[b]				
		OM	CP	ADF	NDF	ADL
1989						
October						
C		88.4	6.6	55.5	84.4	8.0
M		89.4	6.0	55.4	83.3	7.9
1990						
October						
C		89.2	9.0	51.6	80.7	5.6
M		90.1	6.1	54.4	82.8	6.9
December						
C		91.3	4.3	54.7	79.2	4.9
M		87.7	6.6	58.3	83.8	7.6
1991						
October						
C		86.8	10.2	49.0	76.7	6.3
M		87.9	9.1	50.2	78.4	7.0
X	1,537	91.4	8.8	48.8	75.2	6.4
December						
C		86.7	10.3	49.3	72.9	7.8
M		87.8	8.3	52.9	79.0	7.9
X	1,478	92.0	8.6	49.7	75.0	6.2
1992						
October						
C		87.4	9.1	49.4	78.5	10.8
M		88.2	8.8	49.4	77.7	8.4
X	1,192	90.3	10.4	50.1	81.0	8.9
December						
C		88.1	7.7	50.3	79.6	7.2
M		88.3	7.5	51.2	80.4	7.3
X	1,228	91.0	8.6	55.0	83.2	7.7

[a]C = esophageal calves, M = esophageal mature cows or steers, X = clipped.
[b]OM is percentage on a DM basis; all others are percentage on an OM basis.

condition score than cows with small values for S2. Calculation of S1 and S2 values for each cow and including them as well as their interaction in the model as covariates provided a means to account for these size and condition relationships without introducing the colinearity of cow weights and hip height into the analysis of variance models.

Changes in weight and condition score during the experiment are summarized in Figures 2 and 3 with an ANOVA summary for all cow traits in Table 3. Size 1 was positively related ($P < .05$) to weight change, and both weaning and supplement increased weight change ($P < .01$). The effects of weaning (**W**) and supplement (**S**) were highly dependent on year (year × W, year × S, and year × W × S, $P < .01$). The effects on change in condition score were similar to that of weight change except S2 and S1·S2 were the significant ($P < .05$) size covariates. As with weight change, condition score change was affected by weaning and supplement ($P < .01$), but these effects were modified by year (year, year × W, year × S, and year × W × S, $P < .01$).

Forage intake was positively associated with S1 and negatively associated with S2 (both $P < .01$). Nonsuckled cows consumed less forage than suckled cows (16.3 vs 18.1 Mcal of ME/d, $P < .1$), and supplemented cows consumed less forage than nonsupplemented cows (16.3 vs 18.1 Mcal of ME/d, $P < .1$). However, as with weight and condition score change, these effects were dependent on year (year × S and year × W × S, $P < .1$). The total intake (forage + supplement) analysis was the same as for forage intake except that the effect of supplement was removed (no supplement, 18.1 vs 19.5 Mcal of ME for supplement, $P > .2$). Organic matter digestibility was positively related to S1 and was reduced 2% by supplementation ($P < .01$).

The effects that treatments during the fall had on subsequent performance were evaluated by analyzing cow weights, cow condition scores, and calf birth weight at calving the next spring and pregnancy rate of cows and weaning weight of the subsequent calf the next fall. Marked carry-over effects of both weaning and supplementation were observed for precalving cow weight and condition score. Both were related to cow

Table 3. Treatment effects and analysis of variance summary for variables measured on cows

Variable	Averages: Sept. wean	Dec. wean	No suppl[a]	Suppl	ANOVA summary[b]: S1[b]	S2[b]	S1·S2	Wean (W)	Suppl (S)	W × S	Yr	Yr × W	Yr × S	Yr × W × S	df	EMS	$\bar{x}$
Experimental year's data																	
Wt change, kg	28.8	−3.6	3.2	22.1	*	NS	NS	**	**	NS	NS	**	**	**	153	420	13.5
BCS[c] change	.51	−.73	−.38	.15	NS[d]	*	*	**	**	NS	*	**	**	**	153	.41	−.14
Forage intake, Mcal ME/d	16.3	18.1	18.1	16.3	**	**	NS	†	†	NS	**	NS	†	†	94	27	17.1
Total intake, Mcal ME/d	17.9	19.7	18.1	19.5	**	**	NS	†	NS	NS	**	NS	†	†	94	27	18.6
OM digestibility, %	51.9	51.8	52.8	50.8	**	NS	NS	NS	**	NS	**	NS	NS	NS	94	.0014	52
Subsequent year's data																	
Spring wt, kg	573	565	561	577	**	**	†	*	**	**	**	**	*	NS	160	3226	569
Spring BCS[c]	5.9	5.0	5.3	5.7	**	**	NS	**	**	NS	**	**	NS	*	160	1.05	5.5
Calf birth wt, kg	41.9	39.9	40.8	41.0	**	NS	NS	*	NS	NS	NS	NS	NS	NS	148	39.7	40.9
Calf weaning wt, kg	177	180	176	181	*	**	NS	NS	NS	NS	**	NS	NS	NS	141	803	177
Pregnancy rate, %	87.9	84.8	88.3	84.5	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	155	.119	86

[a]Suppl = supplement.
[b]S1 and S2 are size covariates.
[c]BCS = body condition score, 1 = thinnest to 10 = fattest.
[d]NS = not statistically significant.
†$P < .1$.
*$P < .05$.
**$P < .01$.

Table 4. Treatment effects and analysis of variance summary for variables measured on calves and efficiency variables

Variable	Averages: Heref[a]	Charol[a]	No suppl[b]	Suppl	ANOVA summary[c]: S1[c]	S2[c]	S1·S2	Breed (B)	Suppl (S)	B × S	Yr	Yr × B	Yr × S	Yr × B × S	df	EMS	$\bar{x}$
Calf																	
October milk, kg/12 h	2.62	2.84	2.58	2.88	—	—	—	NS	NS	NS	NS	NS	NS	NS	72	.81	2.74
December milk, kg/12 h	1.63	1.77	1.41	1.99	—	—	—	NS	**	NS	NS	NS	NS	NS	70	1.09	1.72
ADG, kg/d	.61	.69	.58	.71	—	—	—	*	**	NS	**	*	NS	NS	72	.029	.65
Forage intake, Mcal ME/d	4.8	5.6	5.5	5.0	—	—	—	*	*	NS	**	**	NS	NS	68	1.18	5.27
Total intake, Mcal ME/d	6.0	6.9	6.5	6.4	—	—	—	*	NS	NS	**	*	NS	NS	68	1.59	6.49
Efficiency, g/Mcal																	
Calf wt/forage ME	32	33	27	38	NS	NS	NS	NS	*	NS	**	†	NS	NS	35	.17	33
Calf wt/total ME	28	30	27	31	NS	NS	NS	NS	NS	NS	**	*	NS	NS	35	.10	30
Cow+calf wt/forage ME	28	30	18	40	NS	NS	NS	NS	**	NS	NS	NS	NS	NS	35	.48	31
Cow+calf wt/total ME	25	26	18	34	†	NS	NS	NS	*	NS	NS	NS	NS	NS	35	.39	28

[a]Calves sired by Hereford or Charolais bulls.
[b]Suppl = supplement.
[c]S1 and S2 are size covariates.
[d]NS = not statistically significant.
†$P < .1$.
*$P < .05$.
**$P < .01$.

size (S1 and S2, $P < .01$). Weaning in September vs December increased precalving cow weight and condition score (565 vs 573 kg, $P < .05$; 5.0 vs 5.9, $P < .01$). Supplementation also increased precalving weight and condition score ($P < .01$). However, as with the fall measurements, these effects were dependent on year interactions (Table 3). As dramatic as some of these effects were during the fall and spring of some years, no carry-over effects were observed on weaning weight of the subsequent calf or pregnancy rate of the cow (Table 3, all comparisons, $P > .2$). Calf birth weight was reduced 2 kg by weaning in December vs September ($P < .05$).

Calf Variables (Table 4)

The first milk production estimate was taken early in the experiment and was not significantly affected by any of the variables ($P > .2$). By the end of the experiment, milk production was decreased, but supplement prevented some of that decrease ($P < .01$). Average daily gains of Charolais-sired calves were greater ($P < .05$) than those of calves sired by Herefords but the magnitude of that effect differed by year (year × B, $P < .01$). Supplementing cows also increased ADG of the calves ($P < .01$). Forage intake of the calf was greater in Charolais-sired calves and in calves on nonsupplemented cows ($P < .05$), but again the effects of breed of sire were dependent on year (year × B, $P < .01$). Total intake of the calf included both forage and milk, and it was greater in Charolais- than Hereford-sired calves ($P < .05$), and the effect depended on year ($P < .05$).

Efficiency (Table 4)

When only calf weight was considered in output, supplement increased efficiency of ME use from forage but not total ME. Both forage ($P < .1$) and total ($P < .05$) ME efficiency were affected by the year × breed interaction and year ($P < .01$). When both cow and calf weights were included in output, supplementation increased both forage ($P < .01$) and total ($P < .05$) ME conversion.

Discussion

Cow size as estimated by S1 and S2 was an important component of the cow data analyses. In general, larger cows (S1) gained more weight, consumed more, and weaned heavier calves, but when efficiency was calculated, these effects mostly canceled out so that there were no effects of size on efficiency. The main objective of including cow size in the analyses was to account for more variation to detect treatment effects, but these general relationships agree with data reported by Adams et al. (1987) and Grings et al. (unpublished data).

The effects of weaning and supplementation on weight and condition score changes during the experimental period as well as precalving the next spring were dramatic in some years but not in others. Cow weights and condition scores at the beginning of the study were consistent each year. However, considerable variation occurred from year to year in precipitation profiles and in quantity and quality of forage available, which were associated with the

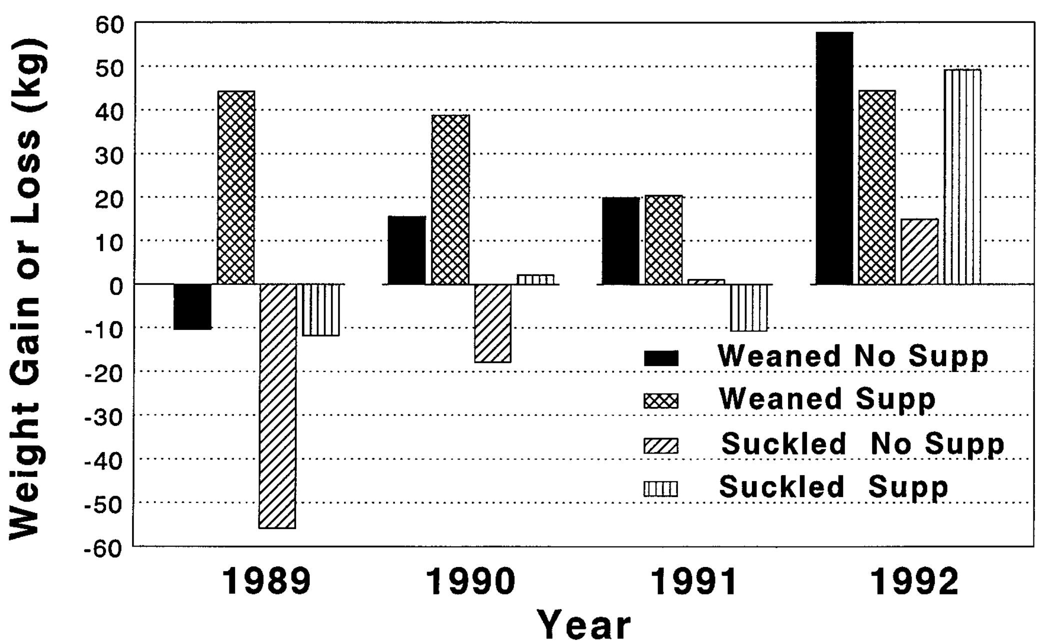

Figure 2. Effect of weaning, supplement, and year on changes in cow weight from September to December.

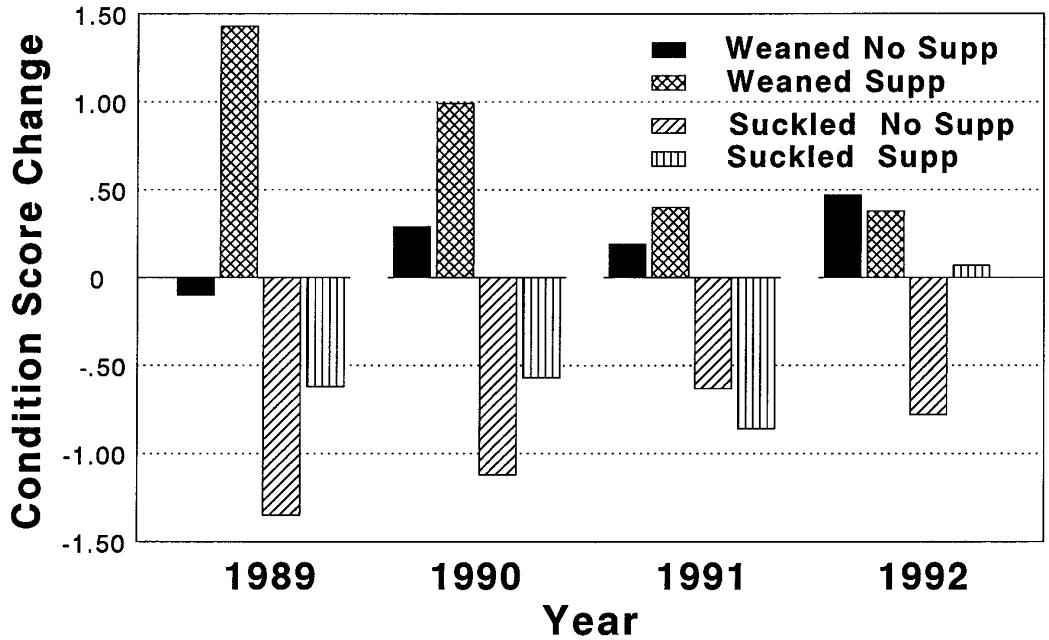

Figure 3. Effect of weaning, supplement, and year on changes in cow condition score from September to December.

variation in response from year to year. No data were found from comparable studies, but, in general, supplementation and weaning should enhance weight and condition score changes (Short et al., 1994). The dramatic effect that year had on response emphasizes that producers must take into account temporal forage and environmental conditions when developing management strategies.

In spite of the treatment effects on weight and condition score during the experimental period that carried over to precalving in some years, there were no carryover effects on subsequent production in terms of pregnancy rate and weaning weights in any of the years. Precalving weight and condition score have been shown to be important determinants of production potential (Richards et al., 1986; Randel, 1990; Kunkle et al., 1994; Wetteman, 1994). Several factors may be involved in this lack of carry-over effects in our study: 1) the cows used in this study were mature, 2) initial weight and condition score were high enough or changes induced by treatments were not sufficiently large to carry over, 3) postcalving nutritional management was sufficient to offset any differences that existed at calving, or 4) our recommendations for body weight and condition score are too high for mature, crossbred cows. There may be opportunities for producers to “sharpen their pencils” and manage for optimum rather than maximum, although the concept of risk management must be included.

Even though supplementation did not have a carryover advantage in subsequent production, supplemented cows whose calves were weaned in December consistently produced more milk and heavier calf weaning weights. Although they did not measure milk production, Adams et al. (1994) showed that calf gains can be improved by placing cows on high-quality meadow pastures (regrowth after earlier hay harvest) vs native range during early fall. Late season protein supplements for cows should be considered as a management tool to enhance weaning weights, especially if weaning is delayed into late fall or early winter.

Supplementation decreased forage intake so there was a partial substitution effect of supplement for forage. Supplemented cows had slightly higher total intakes and lower OM digestibilities. However, the net effect of supplementation was to increase cow weight and condition score, and that effect was dependent on year. Other research has reported similar effects of supplementation on intake (Rittenhouse et al., 1970), the main difference being that energy supplements act as replacements for forage and protein supplements enhance total intake (Kartchner, 1980). Even though the supplement used in this study was principally a protein supplement, it did contain an energy source (barley), which could account for the depression in intake and OM digestibility.

Efficiency was evaluated in two different ways. First, only calf weight change was included as output because calves were the primary product being produced. However, from a biological perspective, and to some extent an economical perspective, both the cow and calf should be included in output. The second method for assessing efficiency included either forage only because of the objective of trying to increase the efficiency of forage utilization or forage plus supplement because both are important for assessing total efficiency. Supplement increased utilization of forage but not total ME to calf weight and dramatically and consistently increased conversion of both forage and total ME to calf and cow weight. As we concluded from calf weights, the primary effects of supplementation on efficiency were immediate rather than long-term, because of the lack of carry-over effects on subsequent production potential.

As expected, breed of sire affected calf response. Charolais-sired calves gained more and consumed more with no net effect on efficiency. However, the breed of sire effect also was dependent on year. The same sires were not used each year, so this interaction was difficult to interpret. The specific sires sampled each year may have resulted in different relative growth potentials each year. In years in which the differential in growth potential was larger, cows with Charolais-sired calves were more efficient. Other researchers have shown sire breed effects on weaning weights (Cundiff et al., 1986; Reynolds et al., 1990). Dinkel (1988) found that cows bred to sires with higher growth potential were 6% more efficient when efficiency was measured for a complete production year.

Implications

When to wean calves and when and whether to supplement cows are major management decisions in a cow-calf enterprise. These decisions affect both economic and production efficiency, but few data are available under Northern Great Plains conditions to aid in making those decisions. Delaying weaning from September until December will usually result in an increase in weaning weight while using native range forage, but that increase in weaning weight will come at the expense of decreased weights and condition scores of the cows in years when forage quantity and(or) quality are limiting. However, with mature cows and adequate nutritional inputs between weaning and breeding the next year, there may be no detrimental carryover effects on subsequent pregnancy rates and weaning weights, even if the delayed weaning has decreased precalving weights and condition scores of the cows. Protein supplementation during the fall will offset the negative effects of delayed weaning in years with limited forage resources and will consistently increase production efficiency and weaning weights, primarily through increased milk production of the cow. The choice of genetic potential for calf growth and propensity to deposit fat will affect calf weaning weight and forage intake but not efficiency.

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